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ONREUR Report

91-1-C

European Space Developments and Programs at the 29th Farnborough International Aerospace Exhibition

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15 February 1991

Office of Naval Research European Office

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a REPORT SECURITY CLASSIFICATION UNCLASSIFIED	1b RESTRICTIVE MARKINGS
2a SECURITY CLASSIFICATION AUTHORITY	3 DISTRIBUTION / AVAILABILITY OF REPORT Approved for public release; distribution unlimited
2b DECLASSIFICATION / DOWNGRADING SCHEDULE	
4 PERFORMING ORGANIZATION REPORT NUMBER(S) 91-1-C	5 MONITORING ORGANIZATION REPORT NUMBER(S)
6a NAME OF PERFORMING ORGANIZATION Office of Naval Research European Office 6b OFFICE SYMBOL (If applicable) (ONREUR)	7a NAME OF MONITORING ORGANIZATION
6c ADDRESS (City, State, and ZIP Code) Box 39 FPO NY 09510-0700	7b ADDRESS (City, State, and ZIP Code)
8a NAME OF FUNDING / SPONSORING ORGANIZATION 8b OFFICE SYMBOL (If applicable)	9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c ADDRESS (City, State, and ZIP Code)	10 SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO / PROJECT NO / TASK NO / WORK UNIT ACCESSION NO

11 TITLE (Include Security Classification)
European Space Developments and Programs at the 29th Farnborough International Aerospace Exhibition

12 PERSONAL AUTHOR(S)
CDR Robert C. Trevino

13a TYPE OF REPORT	13b TIME COVERED	14 DATE OF REPORT (Year, Month, Day)	15 PAGE COUNT
Conference	FROM _____ TO _____	15 February 1991	5

16 SUPPLEMENTARY NOTATION

17 COSATI CODES			18 SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	
22	02		Aerospace
25	02		

19 ABSTRACT (Continue on reverse if necessary and identify by block number)

This report is based on the 29th Farnborough International Aerospace Exhibition, the largest aerospace event of 1990. This major biennial aerospace event is organized by the Society of British Aerospace Companies and emphasized that the trend is toward more international joint ventures among European space organizations and companies. International space cooperation both in the scientific and commercial areas will continue, but European space autonomy in manned and unmanned programs is the long-term goal.

20 DISTRIBUTION / AVAILABILITY OF ABSTRACT ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS	21 ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED
22a NAME OF RESPONSIBLE INDIVIDUAL Ms. Connie R. Orendorf	22b TELEPHONE (Include Area Code) (44-71) 409-4340 22c OFFICE SYMBOL 310

DD FORM 1473, 84 MAR 83 APR edition may be used until exhausted
All other editions are obsolete

SECURITY CLASSIFICATION OF THIS PAGE

UNCLASSIFIED

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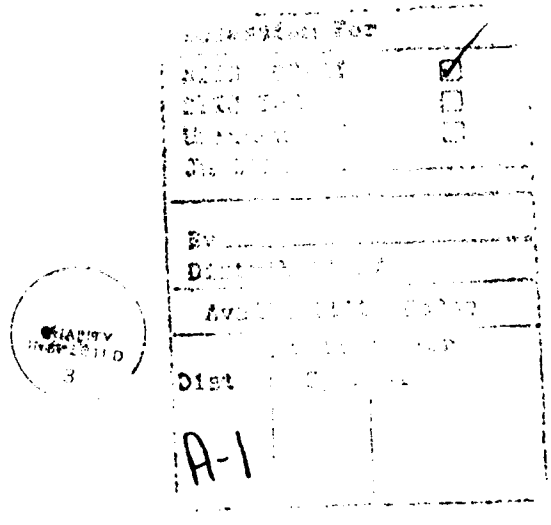

European Space Developments and Programs at the 29th Farnborough International Aerospace Exhibition

Introduction

The 29th Farnborough International Aerospace Exhibition, the largest aerospace event of 1990, was held September 2-9. The Society of British Aerospace Companies organizes this major biennial aerospace event. Farnborough had the expected high attendance, but few new European space programs or initiatives were presented or announced. The European community appears to be maturing its spacecraft technology, especially in the area of launch vehicles, spacecraft design, and satellite communications.

All the major European countries involved in space activities were represented at Farnborough--the U.K., France, Federal Republic of Germany (FRG), Italy, Spain, and the Netherlands. The Soviet Union did not have a space exhibit, but was very active in the aircraft portion of this event. The FRG had the largest and most active exhibit of space programs, components, systems, and research. The British National Space Center (BNSC) was the only government space agency represented.

Because of the wide variety of space topics covered at Farnborough, I present this report by country instead of by programs or specialty. Most space programs in Europe are multinational, either funded proportionally by the European Space Agency (ESA) nor joint commercial ventures where the technology mix is appropriate. The major European countries are also pursuing their own space research and development programs to enhance their technology base for commercial and scientific purposes. European autonomy is the goal of all these efforts in both manned and unmanned space programs. Particular attention was given to new technology demonstrating programs and items of interest to the U.S. Navy.

United Kingdom

British Aerospace (BAe) and Marconi Space Systems were the main British aerospace companies represented. Two government agencies, British National Space Center (BNSC) and the British Remote Sensing Center (BRSC), also participated.

The following is a summary of some of BNSC's technology development programs:

- **Gallium Arsenide (GaAs) Solar Cells.** The BNSC has an active program to improve the performance of GaAs solar cells. Currently, GaAs solar cells with a beginning of life efficiency of 18 percent are commercially available. The GaAs solar cells are very thin and therefore offer the possibility of very light solar cells for a weight-saving on future spacecraft. Since GaAs solar cells have improved performance at high temperatures, BNSC is studying their use in novel solar array designs that use optical concentrators. In this method, solar energy is concentrated using either mirrors or lenses and leads to a much smaller area of solar cells. This research could lead to lighter solar arrays.
- **Closed-Cycle Coolers for Long-Life Space Applications.** Remote sensing instruments that operate in the infrared region require cooling. The BNSC is managing research into improving the sensitivity and signal-to-noise ratio by cooling the infrared detectors to very low temperatures. The Rutherford Appleton Laboratory is performing the actual research. A cooler having 875 MW of cooling power at 80k for 30 watts electrical input power has already been developed and qualified for space applications. This cooler is now commercially available and will be used on the ERS Along Track Scanning Radiometer. A larger multi-state cooler is currently being built as part of a future program concerned with the development for ESA of a long-life 4-K cooler.
- **Along Track Scanning Radiometer (ATSR).** Managed by BNSC and built by the Rutherford Appleton Laboratory, this instrument is designed to measure sea surface temperatures from space to the accuracy of a few tenths of a degree centigrade. The ATSR is part of ERS-1 scheduled to be launched during 1991. Sea surface temperature measurements from the ATSR, together with data from the other ERS-1 sensors (SAR, scatterometer, and altimeter) will enable a better understanding of the complex interactions between the ocean and the atmosphere. High sensitivity on ATSR is achieved by cooling its infrared detectors to liquid nitrogen temperatures using the closed-cycle, sterling cooler discussed earlier. The instrument's accuracy is maintained by an internal calibration facility.

The following is a summary of BAe's only new development:

- **Horizontal Takeoff and Landing (HOTOL).** As background, HOTOL is the BAe and Rolls-Royce proposed unmanned, reusable, single-stage to orbit aerospace plane that would operate from conventional runways. The propulsion system is based on a concept of an integrated dual-role powerplant enabling air-breathing propulsion through the atmosphere when HOTOL's engines

would burn liquid hydrogen and atmospheric air and then switch to a space mode using liquid hydrogen and liquid oxygen. On re-entry to the atmosphere, the engines return to an air-breathing mode. Details of the HOTOL RB.545 engines remain classified secret by the Ministry of Defence. The only new development in the HOTOL program was an announcement by BAe and the Soviet Ministry of Aviation of a 6-month study that would use the giant Soviet An-225 Mriya (Dream) cargo aircraft as a launch platform for a modified version of the HOTOL. This concept, called the Interim HOTOL, would not use the classified RB.545 engines. The Interim HOTOL concept would replace these engines with Soviet-designed rocket engines. The An-225 would carry HOTOL up to 9 km (30,000 ft) and 400 mph. The HOTOL would then be released and use its Soviet rocket engines to reach orbit. The Soviet studies are going to concentrate on the compatibility of the HOTOL and the An-225 to confirm that inflight separation is possible. This study appears to be more an exercise in British-Soviet cooperation than an actual program.

Federal Republic of Germany

In 1990, a major event in the FRG was the merger of the four leading aerospace corporations into one space conglomerate, Deutsche Aerospace (DASA). The DASA was formed to remain competitive in major international projects. The four subsidiaries are Dornier GmbH, MBB, MTN Group, and Telefunken Systemtechnik GmbH. Dornier and MBB are responsible for space systems development. The DASA now has an extremely large technological potential that enables it to undertake any large major international space program.

The following is a summary and status of the new major DASA programs:

- **European Remote Sensing Satellite (ERS).** As background, the French originally proposed SPOT as an ESA program, but were refused. Thus, SPOT is a major commercial French program with minority Swedish and Belgian participation. The ESA decided to create the ERS program to provide images of the Earth in the microwave spectrum. Primary objectives of the multi-mission payload are in oceanographic science; e.g., ocean current patterns, wind velocity, ice coverage. The ESA's radar allows for observations through clouds and darkness. The main payload is the active microwave instrumentation, which consists of a C-band synthetic aperture radar (SAR) with 30-m resolution and a swath width of 99 km. The other payloads are a scatterometer, radar altimeter, along track scanning radiometer, and a microwave sounder. The ESA has approved the funds for two ERS spacecraft. The ERS-1 will be launched on April 1, 1991, on an Ariane V44 launch vehicle; the ERS-2 will be launched in 1994.
- **Modular Opto-electronic Multispectral/Stereo Scanner (MOMS).** An earlier version of this instrument was flown on the space shuttle in 1983 and 1984 when it was mounted on the retrievable Shuttle Pallet Satellite (SPAS). The DASA is currently developing MOMS-02 for cartography and thermatic mapping for the Spacelab D2 mission on behalf of the Federal Ministry of Research and Technology (BMFT) and the FRG Aerospace Research Establishment (DLR).
- **CLUSTER.** The ESA has just recently awarded the contract to DASA/Dornier to develop CLUSTER, a series of four satellites that will study the magnetosphere. CLUSTER is part of the ESA Solar-Terrestrial Science Program (STSP), which is one of four major missions known as the ESA Horizon 2000 Program. The four CLUSTER spacecraft will investigate the sun and the processes in the Sun-Earth environment.
- **SÄNGER.** This MBB program has been present for several years, but there have been some new developments. As background, SÄNGER is a concept for a future European reusable two-stage, low-cost space transportation system for crew and cargo. The first stage will be on air-breathing, turbo-ramjet hypersonic aircraft with cruise capability. The second stage will be a reusable, rocket-propelled winged vehicle called the Hypersonic Orbital Upper State (HORUS) for manned missions or an expendable rocket stage for cargo transport called the Cargo Upper Stage (CARGUS). To demonstrate the technical feasibility, DASA proposes a hypersonic technology experimental aircraft (HYTEX) be built. This will allow testing of key technologies under flight conditions previously not attainable with conventional air-breathing systems. Recently, DASA began testing a gaseous hydrogen-fueled ramjet engine designed to operate at up to Mach 4. This work is leading to an air-breathing propulsion system for the first stage of the proposed SÄNGER.

France

The main French aerospace companies represented were Arianespace, Aerospatiale, Matra, and Alcatel Espace. Matra and the Marconi Space Systems (British) recently formed Matra Marconi Space as a joint venture. The following is a summary and status of some new Arianespace programs:

- **Light Satellite (Lightsat) Launch Services.** Arianespace is the first major commercial launch vehicle company to offer launch services for small satellites. This launch service is for three categories of lightsats: spacecraft weighing up to 800 kgs, up to 1,100 kgs, and less than 50 kgs (microsats). All of these lightsat categories have obvious volume restrictions also. These spacecraft are considered

secondary payloads and must be compatible with the primary payload's requirement. For the heavier spacecraft up to 1,100 kgs, Arianespace has two systems for supporting them. The Spelda Dedicated Satellite (SDS) is used when the launch vehicle is launching two or more satellites simultaneously. The primary payload is carried on top of the SDS. The High Density Satellite (HDS) is used for spacecraft up to 1,100 kg. Also, the HDS is mounted below a primary payload. Microsats are carried aboard a system called the Ariane Structure for Auxiliary Payloads (ASAP). The ASAP can carry up to six spacecraft on a structural ring mounted between the main payload and launch vehicle equipment bay. After the main payloads are deployed, the lightsats or microsats are separated by spring-loaded pyrotechnic devices. Table 1 refers to these lightsat systems and compares them to a main payload. The obvious problem that lightsats have when flying on Arianespace is that they are completely dependent on the main payload for schedule, altitude, and inclinations. The number of mircosats is also dependent on the performance margin that remains on the launch vehicle.

Table 1. Comparison of Lightsat Systems to Main Payload

Ariane Systems	Lightsat Constraints	
	Weight (Kgs)	Volume
SDS	800 Max	10 cm Max
HDS	1,100 Max	10 cm Max
ASAP	50 Max	35x35x60 cm
Primary payload	1,900-4,200	4m DIAx 1m HT

The main program and a new one by Aerospatiale are:

- **HERMES.** The ESA-sponsored reusable spaceplane has been changed drastically since 1989 to reduce its weight. These changes are limiting its operational usefulness and flexibility. The HERMES has no open payload bay. Therefore, it has no capability to carry and deploy spacecraft. The crew has been reduced from six to three. Also, ejection seats have been baselined for HERMES. To reduce the landing weight of the HERMES, many systems that were originally in the vehicle have been moved into a resource module which is completely expendable and are jettisoned at the end of a mission. This module is called the HERMES Resource Module (HRM). The HRM includes an airlock, a docking module that is to be compatible with the International Space Station Freedom, the Soviet Space Station MIR, and the ESA Columbus Free-Flying Laboratory (CFFL). Also, the HRM will have a remotely operated manipulator arm. Apparently, this arm is also expendable at the end of the mission. The HERMES' primary mission will be to service various ESA free-flying platforms in LEO, such as the CFFL. The HERMES program should receive a final go-ahead to start building the spaceplane during a June 1991 meeting of the technical ministers of ESA member states. The HERMES program is a key part of Europe's goal of space autonomy.
- **Study Towards European Autonomous Manned Spaceflight (STEAMS).** This is a new ESA-sponsored study of concepts of autonomous European Space Station (ESS). The STEAMS is mainly developing scenarios for an evolving modular architecture using a combination of elements already planned for use by the Columbus program. An initial ESS would be composed of the CFFL, another pressurized module serving as a habitat and laboratory, and an escape vehicle for emergency crew safety and return. Both unmanned Ariane 5 and HERMES flights would be needed to assemble the ESS. This study emphasizes again the European goal of space autonomy.

Italy

The two major Italian aerospace companies represented were Aeritalia Space Systems Group and Selenia Spazio. Aeritalia Space Systems Group, is the principal national company responsible for Italian Space Agency (ASI), ESA, and commercial programs. The following is a summary and status of the major Aeritalia programs:

- **The ESA Columbus Program.** This programs consists of three key elements:

  1. **Columbus Attached Pressurized Module (APM)** - a permanent part of the international space station Freedom used for microgravity research
  2. **Columbus Free Flying Laboratory (FFL)** - an autonomous laboratory co-orbiting with the space station
  3. **Columbus Polar Platform** - an autonomous platform for carrying payloads for earth observations and scientific experiments.

Aeritalia is prime contractor for the APM and the FFL. The company is directly responsible for the primary structure, the active and passive thermal control, and the development of the internal architecture of these modules. Apparently, Aeritalia is developing the leadership and technology for pressurized modules in Europe.

- **Tethered Satellite System (TSS).** This program is a joint ASI/NASA program. The TSS consists of an instrumented satellite, a thin, flexible tether up to 100-km long, a deployer attached to a spacelab pallet in the space shuttle cargo bay, and scientific experiments on the satellite, as well as in the cargo bay. Two TSS missions are currently planned: (1) an electrodynamic mission using an electrically conducting tether plus satellite deployment spaceward, and (2) an atmospheric mission with the tether and satellite deployed earthward. The first TSS mission is planned for May 1991.

Selenia Spazio was the other major Italian space firm represented. Selenia Spazio is participating in various programs in Europe and the U.S. and is particularly active in telecommunications, remote sensing, and meteorology. In addition, Selenia Spazio is currently involved in the following programs:

- **ITALSAT.** This program is being developed and built for the ASI consisting of a communication satellite operating in the 20/30-GHz frequency band using digital technology and several earth stations for advanced communications and system control. In addition to the 20/30-GHZ digital telephony, the ITALSAT will also have these two missions:

  1. The 20/30 GHZ user services with national coverage to experiment with video conferencing, newspaper transmission, high-bit rate connections between computers, and emergency connections
  2. The 40/50 GH3 propagation experiments with European coverage to collect data for use in the design of future operational communications systems.

- **ARTEMIS.** This is an ESA advanced technology experimental satellite. The ARTEMIS satellite will test and qualify in orbit advanced platform and communications technologies for future missions. The ARTEMIS will consist of three experimental communications payloads:

  1. **Optical Communications Payload (SILEX).** The SILEX payload will be used to carry bidirectional communications in the optical frequencies at a signalling rate of up to 65 Mbit/sec between a geostationary satellite (ARTEMIS) and a Low Earth Orbit (LEO) spacecraft (SPOT 4). The SILEX technology mission also intends to validate the procedures for pointing the optical telescopes installed onboard the spacecraft and demonstrating the on-orbit lifetime of laser-diodes used as transmitters.
  2. **S-band Payload.** This 2,100-2,200 MHZ payload will prove the advantages of phased-array technology for electronic beam scanning. The payload includes two separate antennas, both featuring printed circuit radiating elements and active transmit and receive modules.
  3. **L-band Payload.** This payload will allow bidirectional voice-date communications between fixed earth stations and terminals installed on vehicles; e.g., trucks, cars. The key technologies for the L-band land mobile systems includes developing and qualifying large umbrella-type space antennas of approximately 6-m diameter and new solid-state power amplifiers for frequency reuse.

The ARTEMIS satellite, scheduled for launch in 1994, will also validate some new technologies, such as the ion propulsion subsystem and nickel-hydrogen batteries made in Europe. It is believed that this spacecraft will be the first unclassified program to use laser optics for space data communications.

Comments

The Paris Airshow is held on alternating years and is considered the world's premier aerospace event and the standard for all aerospace exhibitions. However, the Farnborough International Aerospace Exhibition provides a unique opportunity to meet with many European companies involved in space and establish initial contacts for future site visits. The actual displays and hardware are much less than in Paris because the emphasis in Farnborough is on aircraft and related products and services. Paris, on the other hand, very strongly encourages space participation, which also includes a simultaneous space conference. There was very limited U.S. space participation at Farnborough.

As a final observation, there is a trend for more international joint ventures among European space organizations and companies; e.g., Matra and Marconi merger in space projects and the BAe/Soviet Ministry of Aviation joint study. European companies are also becoming associated with American companies; e.g., McDonnell-Douglas and BAe, and Arianespace and Orbital Sciences Corporation. This could be because of the intense competition for future large international space programs. European research; e.g., hypersonic planes like the German SÄNGER and the associated key technologies, will advance with the creation of large conglomerates; e.g., Deutsche Aerospace, that can afford and can focus its resources. International space cooperation, both in the scientific and commercial areas, will continue, but European space autonomy in manned and unmanned programs is the long-term goal.